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BRIDGETON LANDFILL—WEST LAKE LANDFILL

CORE SAMPLING (PHASE 1B, 1C, and 2)
WORK PLAN - REVISION 1

BRIDGETON, ST. LOUIS COUNTY, MISSOURI

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1/8/14

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January 8, 2014

Project No.: BT-012

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Core Sampling Work Plan
(Phases 1B, 1C and 2) – Revision 1
Bridgeton Landfill, LLC

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

This document prescribes the location, technology, and methodology to be used to obtain the data necessary to identify a proposed alignment and develop design information for an isolation/thermal barrier. Installation of an isolation/thermal barrier would prevent migration of a subsurface smoldering event (SSE), if one were to ever occur, within Bridgeton Landfill's North Quarry Area into the adjacent Radiological Area 1 of the West Lake Landfill Superfund site.

Bridgeton Landfill is located within an area that contains the permitted Bridgeton Landfill sanitary landfills (the North and South Quarry Landfills) as well as historic West Lake Landfill (pre-regulation and pre-permitting) sanitary and construction and demolition landfills. Of particular note are two portions of the West Lake Landfill, identified as Areas 1 and 2 where in 1973, soil mixed with leached barium sulfate residue was placed as daily or intermediate cover material over and within solid waste disposed in these areas. The resultant mixture of solid waste mixed with soil containing leached barium sulfate residue is termed radiologically-impacted material or simply RIM. Areas 1 and 2 have been identified by the Environmental Protection Agency (EPA) as Operable Unit 1 of the West Lake Landfill Superfund Site. Remedial actions to address the RIM occurrences within Area 1 and 2 are being directed by EPA (EPA - 2008 and EMSI, 2011).

A SSE is occurring at depth within the South Quarry Landfill. Bridgeton Landfill, LLC has implemented measures such as installation of an ethylene vinyl alcohol cap, installation of additional landfill gas extraction wells, installation and monitoring of temperature probes, and other activities to address the occurrence of an SSE in the South Quarry Landfill. Bridgeton Landfill, LLC is also evaluating potential options for construction of an isolation/thermal barrier to be installed between the North Quarry Landfill and the adjacent Area 1. Bridgeton Landfill, LLC is evaluating these measures as a means to ensure that in the unlikely event that the SSE in the South Quarry Landfill were to spread to, or otherwise occur within the North Quarry Landfill, it could not expand into Area 1.

Prior investigations (RMC, 1982; NRC, 1988; McLaren/Hart, 1996a; and EMSI, 2000 and 2011) provided data that were used to estimate the extent of RIM in Area 1. Data obtained by these investigations indicate that the RIM was present beneath the northern portion of Area 1 and did not extend to the southern portion of Area 1, near the boundary with the adjacent North Quarry Landfill. Bridgeton Landfill, LLC previously determined that placement of an isolation/thermal barrier within Area 1, but outside of the extent of RIM, would be the optimal location for such a barrier. Placement of the isolation/thermal barrier within the southern portion of Area 1 would minimize the depth to which the isolation/thermal barrier would need to be constructed and minimize the amount of refuse that would otherwise need to be excavated and therefore result in reduced time, cost and potential impacts associated with construction of the isolation/thermal barrier.

To this end, Bridgeton Landfill, LLC previously prepared and submitted a Gamma Cone Penetration Test Work Plan (FEI, 2013) to EPA and subject to EPA approval is in the process of performing a detailed subsurface investigation in the southern portion of Area 1. The purpose of this investigation is to identify the optimum location and obtain geotechnical data for an isolation/thermal barrier to be located between Area 1 and the adjacent Bridgeton Landfill - North Quarry Area. This work is being conducted in accordance with EPA's September 20, 2013, letter directing the investigation under the Additional Work provision of the Administrative Order on Consent for the West Lake OU-1 Superfund Site.

A Phase 1 GCPT investigation was recently conducted in the southern portion of Area 1 (FEI, 2013). The purpose of the Phase 1 investigation was to provide initial field screening level data regarding the possible presence of RIM and to provide initial geotechnical data regarding subsurface conditions along potential alignments for the isolation/thermal barrier. A description of the Phase 1 investigation is provided later in this work plan. Results obtained by the Phase 1 investigation are still being evaluated; however, initial review of the field data indicated that RIM may be present beneath the southwestern portion of Area 1 beneath the anticipated western portion of possible alignments for the isolation/thermal barrier. Furthermore, some of the GCPT soundings in the eastern portion of Area 1 encountered refusal at depths shallower than anticipated and therefore it is unclear whether these borings actually reached the base of refuse. Therefore, although originally it was anticipated that the next step in the investigation would be a Phase 2 investigation to obtain specific data along the proposed alignment of an isolation/thermal barrier, based on initial review of the Phase 1 results, it is clear that additional investigation is necessary in order to select an appropriate alignment for an isolation/thermal barrier.

This Work Plan describes the scope and procedures to be employed for the next phase (Phase 1B) of the investigation. In the interest of providing an overview of all anticipated work and to potentially accelerate the overall review time and minimize downtime between the various phases of work, this work plan also describes the anticipated scope of expected subsequent phases of the investigation (e.g., Phase 1C and Phase 2 investigations).

1.1 Project Approach

1.1.1 Site Conditions

In the 1970's West Lake Landfill received various solid and industrial wastes, including soil mixed with leached barium sulfate residues containing traces of uranium, thorium and their long-lived daughter products. The presence of the RIM resulted in the West Lake Landfill being designated as a Superfund site. The RIM is located in two areas at the site: Area 1, which is adjacent to the North Quarry Landfill and thus is pertinent to this investigation; and Area 2, which is located along the northern portion of the site. Area 2 is approximately 1,000 feet (at the closest) from the outer boundary of the North Quarry Area and is separated from it by a road and a closed demolition landfill (Figure 1). Collectively, these two areas have been designated as Operable Unit 1 for the Superfund investigation and remediation activities while the rest of the site was designated as Operable Unit 2.

The southern border of Area 1 is contiguous to the waste mass of Bridgeton Landfill, a quarry-fill landfill containing municipal waste. At the present time, Bridgeton Landfill is experiencing a SSE in its South Quarry Area. While the SSE is currently a significant distance from OU-1 Area 1, Bridgeton Landfill wishes to develop a response strategy to ensure that the SSE does not spread into the Area 1 RIM. Bridgeton Landfill, LLC has committed to constructing a subsurface isolation/thermal barrier located between Bridgeton Landfill's waste mass and the RIM located within West Lake OU-1 Area 1. As directed by EPA, this work will be conducted pursuant to an Administrative Agreement and Order on Consent with EPA.

For purposes of this Work Plan, and in accordance with previous determinations, direction and guidance from EPA (EPA, 1997, 1998, 2010 and 2013, and EMSI, 2011) RIM will refer to waste material containing radionuclides at levels above those deemed appropriate for unrestricted use. Specifically, RIM will include materials that contain combined radium-226 and radium-228 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g); combined thorium-230 and thorium-232 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g); and total uranium greater than 50 pCi/g plus background (e.g. 54.5 pCi/g) [EMSI, 2011].

1.1.2 Proposed Isolation/Thermal Barrier

Bridgeton Landfill has evaluated the possibility of an isolation/thermal barrier as a contingent action to prevent an SSE from advancing from the North Quarry Landfill into the RIM in West Lake OU-1 Area 1. Specifically, Bridgeton Landfill evaluated the excavation of waste to create an isolation/thermal barrier south of the southern limit of radiologically impacted material in Area 1. Such an approach would also limit the volume of waste excavation, consistent with concerns raised by the Lambert-St. Louis International Airport Authority. Finally the relative speed of construction, about three months, would allow such a system to be implemented quickly.

Conceptual evaluation of isolation/thermal barrier designs, reported in the March 29, 2013, letter to Ms. Fitch of the Missouri Department of Natural Resources (MDNR) from Craig Almanza, identified potential alignments along which the isolation/thermal barrier could be constructed. The conceptual evaluation also identified that the amount of material requiring excavation and the depth of such a barrier would be substantially lessened – along with all the negative impacts associated with waste excavation – if the isolation/thermal barrier alignment were moved toward the north. This would allow avoidance of the existing slopes of the North Quarry fill and would reduce the depth of excavation along the eastern portion of the alignment, where quarry activity followed by landfilling would require a much deeper excavation the farther south the isolation/thermal barrier is located.

It is envisioned that the isolation/thermal barrier would be excavated in the non-RIM portions of Area 1, and the purpose of the Phase 1 and Phase 2 Investigations is to identify the alignment for such a location. Alternative methods exist for installation of an isolation/thermal barrier including slurry placement of barrier materials, installation of heat removal/cooling systems, or other techniques. Detailed construction plans for the Isolation/thermal barrier would be submitted for EPA review following conclusion of the investigation work directed by EPA's September 20, 2013 letter (EPA, 2013a).

1.1.3 Overall Scope and Approach of the Investigation

In order to select an alignment and develop the design plans for the isolation/thermal barrier, additional subsurface data are needed for the area between the known extent of the RIM within West Lake OU-1 Area 1 and the Bridgeton Landfill - North Quarry Area. Phase 1 of the project used Cone Penetration Tests (CPTs) to determine the characteristics of the subsurface materials within proposed alignments of the isolation/thermal barrier and the southern edge of the Area 1 fence. The CPT device was also capable of measuring subsurface gamma counts which can increase the likelihood that the proposed isolation/thermal barrier can be constructed without encountering RIM. Regardless of the investigation results, radiological scanning will occur during excavation to construct the isolation/thermal barrier to ensure RIM is not being relocated.

Consistent with EPA direction, the Phase 1 Gamma Cone Penetration Test (GCPT) investigation was the first of what was initially envisioned as a two phased investigation to confirm the isolation/thermal barrier location. The Phase 1 GCPT investigation was to be used to identify a potential alignment and obtain initial geotechnical data for a potential isolation/thermal barrier and was to be followed by a Phase 2 investigation that would confirm the results obtained from the Phase 1 GCPT investigation and further verify the suitability of the proposed alignment. The assumption underlying this approach was that the initial phase (Phase 1 GCPT) of work would not encounter RIM beneath the area of the potential alignment of the isolation/thermal barrier.

Review of the results of the Phase 1 GCPT investigation indicated that RIM may be present beneath the southwestern portion of Area 1 in the area of possible preferred alignments for an isolation/thermal barrier. Elevated gamma readings were obtained from depth intervals of approximately 25 to 35 feet (ft) below ground surface (bgs) in ten (10) of the GCPT soundings drilled in the southwestern portion of Area 1. Specifically, elevated gamma counts were reported in GCPT soundings 1.2, 2.2, 2.3, 3.1, 4.1, 4.2, 5.1, 5.2, 5.3, and 6.3 (Figure 2). The occurrence of RIM in this area was previously unknown as this area falls between approximately seven (7) of the soil borings drilled, downhole-gamma-logged, sampled, and tested for radionuclide occurrences in conjunction with performance of the Remedial Investigation for OU-1 (EMSI, 2000). Furthermore, the depths at which these materials were encountered (e.g., 25 – 35 ft bgs) were sufficiently great that the overlying solid waste provided sufficient shielding such that these materials were not identified by the overland gamma surveys conducted by the NRC (RMC, 1982) or in conjunction with the RI work (McLaren Hart, 1996b) or by the aerial survey recently conducted by EPA (EPA, 2013b).

Because initial evaluation of the results of the Phase 1 GCPT investigation suggest that RIM may be present beneath the southwestern portion of Area 1, additional investigations prior to identification of a potential alignment for an isolation/thermal barrier are needed. Borehole drilling and collection and laboratory analyses of soil/waste samples from this area are necessary to obtain information regarding the nature of the waste materials associated with the Phase 1 GCPT elevated gamma readings and to verify that the elevated gamma levels reported in borings drilled in the southwestern portion of Area 1 reflect the presence of RIM (in contrast to the possible presence of some other material) in this area. In addition, as previously indicated, many of the GCPT soundings drilled in the southeastern portion of Area 1 (e.g., GCPT soundings along alignments 13, 14 and portions of 15 – see Figure 2) encountered refusal at shallow depths.

Consequently, an additional phase (Phase 1B) of investigation is proposed prior to identification of a potential alignment for an isolation/thermal barrier. Phase 1B work would include drilling of additional borings, downhole gamma logging in the borings, and sampling the material responsible for the elevated gamma readings observed in the Phase 1 GCPT borings drilled in the area. Assessing why many of the GCPT soundings drilled during Phase 1 along the east side of the southern portion of Area 1 encountered refusal at shallow depths would also be conducted during Phase 1B. Assuming the material responsible for the elevated gamma readings in the southwestern portion of Area 1 is RIM, a subsequent phase of investigation (Phase 1C) is also envisioned to define the limits of this RIM prior to selection of an alignment for an isolation/thermal barrier. A Phase 2 core sampling investigation would confirm the characteristics (concentrations of isotopic elements, geotechnical data, and nature of fill materials) of the subsurface material along the proposed isolation/thermal barrier alignment.

This Work Plan, along with a corresponding Health and Safety Plan (HASP), is being submitted to detail the locations and procedures to be used to drill soil borings, collect core samples, and perform radioisotope analyses of selected core samples during the Phase 1B investigation. The procedures described in this plan and the previous GCPT Work Plan (FEI, 2013) are also appropriate for work anticipated to be performed as part of the Phase 1C and Phase 2 investigations.

1.2 Goals of the Investigation

The goals and objectives and overall scope of the various phases of the investigation are described below. To minimize delay between the various phases of the investigations, the EPA has requested an expedited development of a Work Plan that addresses the additional Phase 1 investigations and the Phase 2 investigation. At the time this work plan is being authored, the results of the Phase 1 GCPT work are still being evaluated. Therefore, this work plan is focused on the scope and procedures to be utilized to conduct the Phase 1B investigation. In order to expedite performance of the subsequent investigations, this work plan also describes the general scope and anticipated approach envisioned for the subsequent phases of the investigation. The procedures and protocols described in this work plan and the previous Phase 1 GCPT work plan (FEI, 2013) will also be used for the subsequent Phase 1C and Phase 2 investigations. The actual boring locations, drilling techniques (whether GCPT or soil/waste coring) to be used in the subsequent investigations have not been finalized at this time. Addenda to this work plan will be developed to describe the specific drilling locations, drilling and sampling techniques, and other aspects of the Phase 1C and Phase 2 work based on the results of the Phase 1 GCPT and Phase 1B investigations. These addenda will be submitted to EPA once the specific drilling locations and methodologies have been selected for the subsequent phases of work. It is the intention of Bridgeton Landfill, LLC and EPA to expedite the development and approval of these amendments so as to maximize the potential for continuous, uninterrupted investigation and design of an isolation/thermal barrier to the extent possible.

1.2.1 Phase 1 GCPT

Phase 1 of the investigation was focused on collection of information south of and, in some locations, up to the projected extent of RIM material occurrences, in order to confirm the absence of RIM in the location selected for the potential isolation/thermal barrier alignment. The goals of the Phase 1 investigation were to provide confirmatory observations that material within the proposed excavation area for the potential isolation/thermal barrier alignment does not contain RIM and to gather the required geotechnical data for design of the barrier.

The primary goals of the GCPT investigation (Phase 1) were to:

- Determine the stratigraphy, nature, and geotechnical properties of subsurface materials for design purposes,
- Determine liquid levels,
- Determine if any RIM exists within the potential isolation/thermal barrier excavation footprint,
- Determine depth to native material, and
- Use the above information to select the best alignment for the isolation/thermal barrier (proposed alignment).

1.2.2 Phase 1B – Completion/Confirmation Investigation

Initial review of the results of the Phase 1 investigation indicates that previously unidentified RIM may be present beneath the southwestern portion of Area 1. Specifically, elevated gamma readings were measured in GCPT soundings drilled in the southwestern portion of Area 1. One of the goals of the Phase 1B investigation is to obtain samples for laboratory analyses of the eight known isotopes associated with the RIM in OU-1. Therefore, Phase 1B will include drilling of soil borings, performance of downhole gamma logging of the soil borings, collection of samples of the specific material responsible for the elevated gamma readings observed in the Phase 1 GCPT soundings drilled in this area, visual inspection and description of the material associated with the elevated gamma readings, and submission of samples to an offsite analytical laboratory for radioisotope analyses.

Furthermore, many of the GCPT soundings drilled along the east side of the southern portion of Area 1 (e.g., those included in alignments 13 and 14 – see Figure 2) encountered refusal at shallow depths. The cause of this refusal could not be determined from the GCPT work. It may be due to the presence of construction and demolition debris in this area or alternatively may reflect the presence of shallow bedrock in this area. Data regarding the base of the OU-1 landfill wastes are needed in this area. Therefore, additional drilling is required to evaluate the nature of the materials responsible for GCPT refusal in this area and to verify the absence of RIM as well as obtain geotechnical data necessary for selection of a potential alignment for an isolation/thermal barrier through this area (i.e., to complete the objectives of Phase 1). Therefore, several soil borings will be drilled in this area using a drilling method that should be capable of drilling through any construction and demolition debris or the upper portion of any bedrock that may be present in this area to ensure that drilling extends through the entire thickness of refuse in this area.

It also necessary to obtain laboratory analytical data from known, unimpacted boring locations to assist with determination of background gamma levels and radioisotope activities associated with non-RIM waste and in situ soils. Therefore, soil/waste samples will be obtained from Phase 1B borings drilled in the eastern portion of Area 1 that do not display elevated downhole gamma readings. Samples will also be obtained from any borings/depth intervals where elevated gamma readings are encountered in the boreholes drilled in the eastern portion of Area 1.

1.2.3 Phase 1C – Delineation of the Extent of RIM

In order to select a proposed alignment for an isolation/thermal barrier, additional characterization of the area of elevated gamma readings in the southwestern portion of Area 1 will likely need to be performed, presuming that the results of the Phase 1B investigation indicate that these readings reflect the presence of RIM in this area. Although the logical approach for such an investigation would be to perform additional GCPT soundings outside of this area, use of the GCPT drilling technique may not ensure complete delineation of the extent of elevated gamma readings in this area. Besides the potential for refusal at depths less than the full depth of refuse as encountered in the eastern portion of Area 1, drilling to define the extent of RIM may necessitate drilling along and through the slope of the North Quarry Landfill, the waste deposits of which overlap the southernmost portion of Area 1. The depth of drilling required in this area could potentially exceed the maximum effective depth of the GCPT drilling rig (approximately 70 to 100 ft). Therefore, delineation of the extent of possible RIM in the southwestern portion of Area 1 may require performance of sonic drilling or a combination of GCPT and sonic drilling. The proposed approach for completion of this delineation will be addressed in an addendum to this Workplan.

1.2.4 Phase 2 Core Sampling Investigation

The objective of Phase 2 of this project is to collect soil core samples from a limited number of locations and analyze the samples for the presence or absence of RIM as well as to confirm the characteristics of the subsurface material along the proposed isolation/thermal barrier alignment determined from the GCPT. The Phase 2 investigation will also be used as a verification of the GCPT methodology and interpretations for the geotechnical data.

Based on the results of the Phase 1 investigations, an initial conceptual design for an isolation/thermal barrier will be developed. The initial conceptual design will include a summary and evaluation of the Phase 1 investigation results, a proposed alignment for the isolation/thermal barrier, the anticipated barrier technology, and the general approach anticipated to be used for installation of the barrier. Based on the initial conceptual design, additional data necessary for finalization of the proposed alignment, isolation/thermal barrier design and construction techniques will be identified. Currently it is anticipated that the isolation/thermal barrier will be installed by excavation of refuse followed by placement of an earthen barrier along the north side of the excavation, followed by backfilling of the remainder of the excavation with refuse removed from other portions of the excavation. Upon completion, the EVOH cap being installed over the North Quarry Landfill will be extended over the isolation/thermal barrier and excavation areas.

Assuming the isolation/thermal barrier is constructed by excavation of existing refuse, the primary goal of the Phase 2 core sampling investigation will be to quantify subsurface concentrations of isotopic elements within the isolation/thermal barrier construction area. This will involve:

- Installation of a sufficient number of boreholes to verify the GCPT data within the isolation/thermal barrier excavation limits~~;~~
- Produce geophysical and radiometric logging data from each soil core;
- Collect samples of soil materials from each length of the borehole (minimum 2 per borehole);
- Generate downhole gamma logs that will be used to prioritize sample analysis from the borehole samples collected;
- Submit soil samples to a certified, independent laboratory for radioanalyses;
- Determine type of waste/subsurface material (e.g., rock, municipal solid waste, construction and demolition waste); and
- Determine the necessary chemical analyses of the Investigation Derived Wastes, so that the soil cores may be properly disposed after all analytical testing has concluded.

The design process will use the results of the Phase 1 investigations to conceptually design the isolation/thermal barrier. Data such as depth of waste, liquid levels, width of isolation/thermal barrier, allowable slopes, and staging requirements will be used in the alignment and "daylight" line projections, which will guide the coring location selection.

2 PREVIOUS INVESTIGATIONS

Previous investigations in the vicinity of a potential alignment for a subsurface isolation/thermal barrier between Area 1 and the Bridgeton Landfill North Quarry Area did not contemplate construction of a physical structure; therefore, geotechnical data necessary to design a barrier does not exist. However, previous investigations have identified the presence of RIM in Area 1 of the West Lake Landfill using downhole gamma radiation logging of soil borings, collection and analyses of surface and subsurface soil samples, and overland gamma surveys.

2.1 PRIOR INVESTIGATION METHODS

Downhole gamma radiation logging and overland gamma surveys were used as the primary RIM detection methods for these investigations. In addition, samples were collected from soil borings for analyses of uranium, radium, thorium isotopes and their decay products as well as for non-radiological constituents. Results of these investigations are presented in the Soil Boring/Surface Sample Investigation Report (McLaren/Hart, 1996a) and the OU-1 Remedial Investigation Report (EMSI, 2000). Eight radionuclides were identified as contaminants of concern based on their long half-lives: Uranium-238, Uranium-234, Thorium-230, Radium-226 and Lead-210 from the Uranium-238 decay series; Uranium-235 and Protactinium-231 from the Uranium-235 decay series, as well as Thorium-232 and its progeny. Isotopes from the Thorium-232 decay series are also present at levels above background, although to a lesser extent.

2.2 RESULTS OF PREVIOUS INVESTIGATIONS IN AREA 1

Downhole gamma logging by McLaren/Hart in Area 1 found elevated radiation levels varying from zero to sixteen feet bgs, while the thickness of the materials generally ranged from one to five feet in Area 1. In the northwest region of Area 1, elevated readings ranged from zero to six feet bgs, while to the southeast, elevated readings were found as deep as 15 feet bgs. The estimated extent of the impacted area is illustrated in Figure 2.

An overland gamma survey (McLaren/Hart, 1996b) also detected gamma radiation above background at the ground surface. Laboratory analyses of surface soil samples (the upper 6 inches) detected radionuclides at levels above 5 pCi/g above background at boring locations WL-106 and WL-114.

The 2011 Supplemental Feasibility Study (SFS) [EMSI, 2011] included a detailed estimate of the extent of RIM in Area 1. An outline of the known impacted material was created using the available boring data, as well as an outline of the known non-impacted area (see SFS Appendix B-2, Figures 3 and 4). Based on these boundary conditions, the estimated limit of the RIM in Area 1 was interpolated between these two boundaries. These boundaries, the interpolated RIM limits, and borings used to estimate the limits are shown in Figure 2 of this Work Plan.

The SFS delineation of the extent of RIM was sufficient for purposes of developing and evaluating potential remedial alternatives for OU-1. However, construction of the isolation/thermal barrier requires a high degree of confidence that the alignment for the isolation/thermal barrier is located outside of the extent of RIM. Therefore, as part of geotechnical investigation of the proposed alignment, data are also being obtained to confirm that the selected alignment is outside the location of RIM above levels for unrestricted use.

3 GCPT INVESTIGATION (PHASE 1)

The scope of the Phase 1 GCPT Investigation was detailed in the September 27, 2013, document entitled "Bridgeton Landfill – West Lake Landfill Gamma Cone Penetration Test (GCPT) Work Plan Revision 2" prepared by Feezor Engineering, Inc., P.J. Carey and Associates, Engineering Management Support, Inc., and Auxier and Associates, Inc. This work plan described the procedures and protocols to advance a piezocone sounding in an area between the known RIM area in Area 1 of OU-1, and the southern edge of OU-1 Area 1. During the investigation, data regarding the stratigraphy, nature, and geotechnical properties of the materials as well as liquid levels, as they relate to the design of a isolation/thermal barrier system were collected with each piezocone sounding. In the same CPT sounding, gamma radiation logging was performed using a proprietary device that is included in the equipment tool string behind the GCPT head. The device used a Cesium Iodide crystal. The device differs from a typical downhole logging gamma detector in that it is part of the push rod system and therefore has greater shielding from the thicker rod walls and is smaller in diameter for the same reason. However the device has been used successfully on other projects to detect the differences between clays and silts.

Tip force, sleeve force and pressure were all recorded as the push rods were advanced. Reading intervals were taken at intervals not exceeding 50 mm. The advance rate of the probe was approximately 2 cm/second, which is the American Society for Testing and Materials (ASTM) Standard.

The type of soils, including waste materials, was inferred based on the analysis of the combination of tip, sleeve and pore pressure while advancing (referred to as dynamic pore pressure). Work at other sites has demonstrated that interfaces between waste material and natural soil can be identified using CPT technology.

The activities described in the approved work plan involved conducting an overland gamma scan in the area between the known RIM area in Area 1 of OU-1 and the southern edge of OU-1 Area 1, clearing brush and vegetation to deploy a geotextile and stone to provide all-weather roadways for investigative equipment, advancing GCPT borings, and evaluating results. All equipment and personnel followed the radiological screening and safety protocols as discussed with the Phase 1 work plan and complementary HASP.

Initial results of the Phase I GCPT work are presented on Figure 2. Initial review of the results of the gamma logging of the GCPT soundings indicate that elevated gamma readings were present in some of the GCPT soundings drilled in the southwestern portion of Area 1 and to the west of the previous OU-1 western boundary. Borings with reported elevated downhole gamma readings include the following:

- GCPT 1.2
- GCPT 2.2
- GCPT 2.3

- GCPT 3.1
- GCPT 4.1
- GCPT 4.2
- GCPT 5.1
- GCPT 5.2
- GCPT 5.3
- GCPT 6.3
- GCPT 8.1 (possible)
- WL-119 (possible)

Subject to the results of the Phase 1B drilling program, additional drilling may be necessary to further delineate the extent of elevated gamma levels/RIM in this area.

Please note that the following soundings warrant additional investigation once the analytical data are obtained from the Phase 1B investigation, as the gamma counts pertain to the background level. These sounding include the following:

- GCPT 7.3
- GCPT 11.4
- GCPT 15.1
- GCPT 15.3

Also note that other GCPT soundings encountered elevated gamma counts which were not unexpected due to their proximity to known RIM boundaries. These include the following:

- GCPT 12.1
- GCPT 13.1
- GCPT 14.1
- PVC 25
- PVC-28
- PVC 36 (also called GCPT 6.1)

As previously discussed, a number of borings along the eastern side of Area 1 encountered refusal at shallow depths and therefore may not have reached the base of refuse. Borings that encountered shallow refusal include the following:

- GCPT 13.2
- GCPT 13.3
- GCPT 13.4
- GCPT 13.5
- GCPT 13.6
- GCPT 13.7
- GCPT 14.2

- GCPT 14.3
- GCPT 14.4
- GCPT 14.5
- GCPT 14.7
- GCPT 15.2
- GCPT 15.8 (Possible)
- GCPT 16.3 (Possible)
- GCPT 16.4 (Possible)
- GCPT 16.5 (Possible)
- GCPT 16.6 (Possible)
- GCPT 16.7 (Possible)
- GCPT 16.8 (Possible)

Additional drilling will be needed to assess the source of the refusal encountered in these borings (i.e., shallow bedrock, construction and demolition debris, other material) and to determine the depth of refuse in this area.

4 PROPOSED INVESTIGATIONS

4.1 OVERVIEW OF TECHNIQUE

As stated previously, the purpose of the GCPT investigation is to verify the absence of RIM in the area where excavation would be performed to construct an isolation/thermal barrier. The GCPT investigation will provide qualitative data regarding the presence and nature of the materials encountered and was not intended to be quantitative. After review of the initial data obtained from the GCPT investigation (Phase 1), the proposed location for the isolation/thermal barrier will be determined. Select locations within the area of potential excavation for construction of an isolation/thermal barrier will then be core drilled to a depth 10 feet below the waste materials. Samples will be collected for analytical testing for radiological isotopes and geotechnical property characterization.

The soil core samples will be collected using sonic drilling technology. Samples for radiochemistry analyses will be collected using Auxier & Associates Procedure 3.3 (included in **Appendix A**). The soil samples will be taken at various depth locations of the core boring sample subject to where soil materials are encountered in each boring. Biased samples will be taken at locations of radioactivity as identified by field radiation detection instruments. Other samples will also be taken where no radiation is detected by such radiation detection instruments.

4.2 LOCATION OF BOREHOLES

4.2.1 Phase 1B Investigation – Completion/Confirmation Investigation

As discussed above, soil borings, collection of core samples and submittal of laboratory samples are needed to further evaluate the reported elevated gamma values obtained during the Phase 1 GCPT investigation. In order to verify whether the elevated gamma readings obtained during Phase 1 represent RIM, samples must be obtained and submitted for laboratory analyses for radium, thorium and uranium isotopes. It is not necessary to collect samples from all ten of the locations with elevated gamma readings to verify whether the elevated gamma readings reflect occurrences of RIM. Collection of soil cores and samples from five of the ten GCPT soundings with elevated gamma readings is considered sufficient to verify whether the elevated gamma readings correspond with occurrences of RIM. Therefore, drilling and collection of soil cores are proposed to be performed at or adjacent to the following locations:

- GCPT 5.3 – the GCPT sounding with the reported highest gamma reading
- GCPT 2.2 – a GCPT sounding with an intermediate level gamma reading
- GCPT 1.2 – the westernmost GCPT sounding with an elevated gamma reading
- WL-119 – a GCPT sounding with a slightly elevated reading at 45.6 feet, in which analytical isotopes are needed to understand the elevated reading

- GCPT 8-1 – a GCPT sounding that had a slightly elevated reading at 29 feet, in which analytical isotopes are needed to understand the elevated reading

In addition, eight borings are proposed for the area where the GCPT soundings encountered refusal at shallow depths. The proposed locations and rationale are provided below:

- GCPT 12.5 – a southern location along path 12 to determine the elevation of the bedrock
- GCPT 13.3 – the northernmost location along line 13 where shallow refusal occurred
- GCPT 14.2 – the northernmost location along line 14 where shallow refusal occurred
- GCPT 14.4 – a location in the center portion of the area where shallow refusal occurred
- GCPT 14.7 – the southernmost location where shallow refusal occurred
- GCPT 15.2 – the only location along line 15 where shallow refusal occurred
- GCPT 16.3 – the northernmost location the potential isolation/thermal barrier alignment along Path 16
- GCPT 16.6 – a mid-path alignment check location of the bedrock elevation

After these borings are conducted and the bottom of waste is better understood, then it will be determined which GCPT soundings on the east side encountered refusal due to bedrock, and which GCPT soundings encountered obstructions. The GCPT locations that were deemed to be shallow due to obstructions will be reinvestigated within the Phase 2 investigation by either sonic drilling techniques, or a modified GCPT sounding method that would involve coring the first 10 feet of the GCPT sounding and backfilling the 10 feet initial hole with sand, then allowing the GCPT to scan the entire depth. This procedure will be discussed with the EPA prior to initialization.

4.2.2 Phase 1C Investigation – Delineation of the Extent of RIM

The eastern, northwestern, and southern extents of the elevated gamma occurrences in the southwestern portion of Area 1 can be delineated based on the results of the Phase 1 GCPT investigation and the results obtained during the RI investigation. Specifically, elevated downhole gamma readings were not encountered in GCPT soundings GCPT 6.2, 6.4, 6.5, and 7.2 located along the eastern margin of the area where elevated gamma readings were identified (Figure 2). Furthermore, neither elevated gamma readings nor radionuclide occurrences above those used to identify RIM were encountered in RI borings WL-107, WL-116 and WL-119 (McLaren Hart, 1996a and 1996b and EMSI, 2011). Therefore, the eastern extent of the area with elevated gamma readings has been defined (see Figure 2).

The northern extent of the area with elevated gamma readings (i.e., north of GCPT 3.1, 5.1, and 5.2) has not been defined. The occurrence of elevated gamma levels could extend from these borings to the north up to the area where RIM was previously identified as being present in the northwestern portion of Area 1 (e.g., in RI borings WL-105B, WL-102, WL-106B and NRC boring PVC-36) or the area of elevated gamma levels identified in the Phase 1 GCPT soundings may terminate before reaching the northern edge of the area previously identified as containing

RIM (see the redline boundary shown on Figure 2). Regardless of which of these conditions exist, additional characterization to the north of the existing Phase 1 GCPT soundings is not needed for the isolation/thermal barrier evaluation, as the proposed location for the isolation/thermal barrier would be to the south of the area of the elevated gamma readings.

GCPT soundings 1.1 and 2.1 along with RI boring WL-124 define the northwestern extent of the area with elevated gamma readings. Downhole gamma logging of boring WL-124 did not detect elevated gamma readings or radionuclide activities above the unrestricted use levels; however, no soil was encountered in the waste materials in this area so the only sample obtained and submitted for laboratory analyses from this boring was obtained from the ground surface. Based on the combined results from the two GCPT soundings and the RI boring, additional drilling is not needed to delineate the northwestern extent of elevated gamma readings.

The western extent of elevated gamma readings, to the west of GCPT boring 1.2, has not been defined; however, there is only approximately 25 ft of open ground between GCPT sounding 1.2 and the existing transfer station building. Therefore, only one additional boring could potentially be drilled in this area (subject to inspection of the area and utility clearance to determine actual suitability for additional drilling). The existing soil boring array also does not define the extent of elevated gamma readings to the south of boring GCPT 1.2, so an additional boring may also be required in this area.

The overall southern extent of the area of elevated gamma readings can be generally defined by GCPT soundings 3.2, 5.4 (still need to investigate background levels for 5.4), 6.4 and 6.5 and RI borings WL-107, WL-121, WL-122 and WL-123 which did not detect elevated gamma readings or radionuclide activities above the unrestricted use levels (however, although elevated downhole gamma readings were not measured in borings WL-121, -122, and -123, soil was not encountered in the waste materials in these borings so the only samples obtained and submitted for laboratory analyses from these borings were collected from the ground surface). Significant separation does exist between some of the RI borings (e.g., between GCPT 4.2 and WL-122) so the exact limits of the elevated gamma readings in this area are not precisely known. Because this area may be represent a potential alignment for an isolation/thermal barrier, additional drilling in this area is recommended.

Tentative boring locations to further define the extent of the elevated gamma occurrences are provided on Figure 3. The exact number and location of additional soil borings to address this objective will be determined based on the results of the Phase 1B drilling, logging, and sampling activities in the area of the elevated gamma readings identified by the Phase 1 GCPT program.

4.2.3 Phase 2 Core Sampling Investigation

As previously discussed, additional data are required to determine an appropriate location and alignment for an isolation/thermal barrier. The specific alignment cannot be determined until evaluation of the Phase 1 GCPT investigation results is completed and the Phase 1B and 1C investigations have been performed. After completion of all Phase 1 investigations, a proposed alignment and conceptual design for an isolation/thermal barrier will be developed. Once the proposed alignment is determined, locations for Phase 2 borings can be identified. The specific number and locations of borings for the Phase 2 program will be determined based on the results of the Phase 1 GCPT, Phase 1B and Phase 1C investigations. It is anticipated that the proposed locations of the Phase 2 boreholes will be distributed at regular intervals along the proposed alignment. An addendum to this work plan will be prepared to present the locations of the Phase 2 borings.

4.3 Boring Techniques

4.3.1 Sonic Drilling

The MDNR suggested a coring procedure such as sonic drilling within their August 20, 2013, letter to the Bridgeton Landfill, LLC. Therefore, the sonic drilling technique will be used to advance the borings and collect core samples.

Sonic drilling conducted in accordance with ASTM D6914 will be used for the advancement of a continuous core for each borehole. ASTM D6914 provides guidance and discussion about this technique which is summarized in this section.

Sonic drilling is used for geo-environmental investigative programs. Sonic drilling offers the benefit of significantly reduced drill cuttings and reduced fluid production. Furthermore, sonic drilling does not entail the use of any drilling fluids such as air or water to circulate cuttings (water may be used to cool the downhole equipment) and therefore does not result in any form of emissions at the ground surface. The continuous core sample recovered by the sonic drilling technique provides a representative lithological column for review and analysis. The ability to cause vibration to the casing string eliminates the complication of backfill bridging common to other drilling methods and reduces the risk of casing lockup allowing for easy casing withdrawal during grouting.

The cutting action, as the sonic drilling bit passes through the formation, may cause disturbance to the soil structure along the borehole wall. The vibratory action of directing the sample into the sample barrel and then vibrating it back out can cause distortion of the specimen. Core samples will be hydraulically extracted from the sample barrel to reduce distortion. The use of split barrels, with or without liners, may improve the sample condition but may not completely remove the vibratory effect.

Some of the GCPT soundings were unable to be advanced due to large concrete construction and demolition debris fill encountered during the sounding. The sonic rig will be able to penetrate these fill materials. Sonic drilling through construction and demolition debris material may require the use of fluid (no air drilling allowed) to remove drill cuttings from the face of the bit, as they generally cannot be forced into the formation.

Some heat generation may occur within the borehole due to the use of sonic drilling. Liquid (potable water) will be injected down the drill string to reduce potential heat generation. Use of liquid will also increase core recovery. No liquid return to the top of the boring is anticipated.

4.3.2 Other Techniques

GCPT drilling may be used to further delineate the extent of elevated gamma readings in the southwestern portion of Area 1 (i.e., the Phase 1C investigation). A decision regarding the potential applicability of further GCPT drilling will be made based on the results of the Phase 1B investigation and may include comparison of the relative merits of GCPT and sonic drilling techniques. If additional GCPT drilling is determined to be suitable, the procedures for conducting such drilling will be the same as those used during the Phase 1 investigation as described in the prior Phase 1 work plan (FEI, 2013).

4.4 SITE PREPARATIONS

The selected location for a given soil boring will be located and marked by a land surveyor before sampling will begin at that location. These locations will be surveyed, horizontally and vertically, using the local Site coordinate system and recorded.

4.5 EQUIPMENT PREPARATION AND SAFETY TRAINING

Equipment will be in proper working order and inspected to determine if it meets safety requirements per Auxier & Associates Procedure 2.1 in **Appendix A**. Personnel will be briefed on potential hazards including working around moving equipment, physical hazards, biota, and risks associated with radiological or chemical exposures. Health and Safety Protocol/Procedures pertaining to general and radiological aspects of drilling in impacted areas are included in the HASP.

It is anticipated that all work will be completed in modified OSHA level D personal protective equipment (PPE), as required by the Auxier & Associates Radiation Safety Officer or his on-site designee (RSO). Respirators for protection from radionuclide exposure will not be routinely required but will be made available to workers. Respirators for protection from dust inhalation may be used if there are continuous plumes of visible dust from the borehole or soil cores; however this condition is not anticipated to occur. Application of water during drilling should alleviate this situation. A decision to require use of respirators may be made by the RSO if conditions are encountered that warrant use of respirators for protection from dust or radionuclides.

Survey instrumentation will be calibrated and documentation of calibration will be available for inspection. Sampling equipment and industrial hygiene monitoring equipment will be in proper working order and documentation of calibration (if applicable) will be available for inspection. A daily instrument response check will be performed on all radiological instruments used for quantitative measurements before the instruments are used. The results of these response checks will be recorded and retained for inspection.

4.6 Surface Radiation Measurements

Drill sites and access paths to drill sites will be surveyed by the RSO prior to entry or the start of any drilling activities. The RSO will conduct an overland gamma scan of the drill sites and access roads to the extent that such surveys were not previously performed in conjunction with the Phase 1 GCPT investigation. The same procedures used for the Phase 1 GCPT surveys will be used for any surveys performed in conjunction with the Phase 1B and 1C or Phase 2 work. These procedures were previously presented in the Phase 1 GCPT work plan (FEI, 2013); however, for completeness, the procedures to be used are included below.

For any areas without previous surface scans in the Phase 1 investigation, a Ludlum 2221 ratemeter/scaler mated to a Ludlum 44-20 3x3" NaI detector (or equivalent equipment) will be used to survey selected portions of ground surface within and around Area 1. This instrument will be coupled to a Trimble GPS and operated in the ratemeter mode. This mode will allow the gamma count rate from the instrument to be collected at one-second intervals and assigned to its specific measurement location (latitude and longitude). The operator will hold the detector approximately 30 cm above the ground surface and advance across the areas of interest in a series of straight lines at a rate of approximately one meter per second. The separation distance between the lines will be approximately 1.5 meters. After the survey, the field data will be processed using a combination of industry standard commercial computer applications. Because all data points will be tied to a spatial coordinate, a map of the data will identify areas of surface soil containing RIM. These areas can then be located in the field and avoided or covered. If the overland gamma scan indicates a radiological level over background, the RSO will notify the clearing crew that they could be in an area that has surface RIM and to proceed in a manner that avoids ground disturbance. The path to each borehole location will be cleared of vegetation 10-20 feet wide in the general direction dictated by the onsite surveyor. The cleared path and the path to be cleared (as much as practicable) will be scanned with the overland gamma scanning equipment; then the next section will be cleared. This procedure will be used in the same sequence until the desired borehole location has been reached. It is envisioned that paths to each borehole location will be approximately 10-15 feet wide, while a larger area (25-30 feet diameter) will be cleared at each borehole location.

Exposure and dose rates will be measured over each borehole location before drilling starts. In addition, thermoluminesent dosimeters (TLDs) or equivalent will be installed 1-meter above a minimum of three (3) marked boreholes. These TLDs will be collected after 10 weeks or before isolation/thermal barrier installation, whichever is sooner, and sent to the vendor for processing. These measurements will be used to document exposure rates within Area 1.

4.7 Borehole Sampling

The investigation activities will be conducted using sampling technology associated with the sonic drilling technique (ASTM D6914). The Sonic drilling crew will proceed to each marked borehole location and continuous soil cores will be collected and logged.

At each boring location, soil cores will be advanced through any overburden and into the underlying landfill deposits, terminating in the underlying unconsolidated material. If refusal is met, the borehole location may be off-set at the discretion of the Project Manager. It is anticipated that the total depth of each borehole will be approximately 30 to 60 feet bgs but may extend as far as 80 feet bgs in places. Soil cores from these boreholes will be labeled with a unique sample identification number that will include a reference to the boring designation from the sampling map, the borehole number (if more than one borehole is taken at the same location), the core sequence number or depth interval, an arrow indicating the top of the soil core, and the date.

Soil cores obtained from each borehole will be examined by the project geologist/field engineer. At a minimum, the geologist/field engineer will identify the depths that soil transitions from one subsurface unit to the next and identify any stratum that may affect the installation or efficacy of the isolation/thermal barrier. The entire soil core from the borehole will be stored in sealed PVC pipes.

4.8 Subsurface Measurements

An integrated procedure using vertical scanning of the borehole (borehole gamma logging) and gamma scanning of the produced soil core will be used to identify subsurface gamma anomalies and match soil samples with those anomalies. Borehole logging will be used to assess whether measureable amounts of elevated subsurface gamma radiation exist in the borehole, and to determine the depth and thickness of any subsurface anomalies. Soil core gamma logging will be used to locate any soils in the sample tube that may produce elevated levels of gamma radiation. This integrated approach will allow samplers to identify the depth(s) of potentially impacted soils (indicated by the downhole gamma logs) even if the soil column in the sampling tube is displaced to a different depth in the tube during sampling.

4.8.1 Borehole Gamma Logging

Once the borehole has reached its total depth, a 2 ½ inch minimum solid PVC pipe with a bottom capwill be inserted into the hole. The boring diameter should be approximately 6 inches, so an annular space will exist. This annular space will be backfilled with sand from the surface once the borehole gamma logging has concluded. A bentonite seal will be used in the upper 5 feet of backfill. The PVC pipe will extend 4 feet above the surface, and a PVC endcap will be secured to the finished PVC pipe before the borehole has been completed.

A 1-inch NaI gamma probe with a long cable will be lowered into the sleeve and used to record one (1) minute radiation measurements at 6-inch intervals along the length of each borehole. These measurements will be recorded in counts per minute (cpm) and the depth of each measurement will be recorded as depth bgs in negative feet. For example, the depth of a gamma measurement taken at 3.5 feet bgs will be recorded as "-3.5 feet". This "gamma log" will be used to identify the depth bgs of any subsurface soil layers producing elevated radioactivity. A modified borehole logging procedure excerpted from the Auxier & Associates procedure manual is provided in **Appendix A**.

4.8.2 Soil Core Gamma Scanning

Concurrently with borehole gamma logging, any radioactivity associated with the soil core will be determined by taking 1-minute integrated gamma measurements at 1-foot intervals using a 3x3 inch NaI gamma detector along the length of the core(s) that contains the upper strata of fill and refuse material. After all measurements have been taken along the soil core tube, samples for laboratory analysis will be collected from those core intervals producing anomalous results. For the purpose of this work plan, anomalous areas are those intervals of soil producing a gamma response that is 30% greater than the median of all gamma responses observed for the same borehole. This 30% criterion, referred to as the Elevated Measurement Location (EML) criterion, is adapted from New Jersey's Field Sampling Procedure Manual dated 12.7.10. The procedure from this manual was selected because it provides a citable procedure developed by a reputable third party (New Jersey Department of Environmental Protection's Bureau of Radiation.)

4.8.3 Geological Examination of Soil Core

The project geologist/field engineer will review the core samples and log the boring based upon the cores and the corresponding depths. A geologic log for each boring will be developed.

4.9 SOIL SAMPLING

Soil samples will be collected based upon the results of the borehole gamma logging, soil core gamma scanning, and geological evaluation of the contents of the soil core. At a minimum, all anomalous intervals of the soil column identified in Section 4.8 will be sampled. Additional intervals of interest may be selected for discretionary sampling by the project geologist/engineer or RSO. At a minimum two (2) soil samples will be collected from each boring.

When sampling, the associated 1-foot interval of soil collected will be identified in the field notes for that tube and the sample associated with that interval will be sent for analysis at the analytical laboratory. The depth of the sample will be determined by measuring from the ground surface.

The volume of soil sample, type of sample container, and preservation requirements are provided on Table 1. Soil samples will be analyzed for isotopic Uranium, isotopic Thorium, and gamma spectroscopy at the Eberline Services Oak Ridge Laboratory located in Oak Ridge, TN using the methods listed in Table 1. Method Detection Activities (MDAs) for these methods are also indicated on Table 1.

Field duplicate samples will be collected at a frequency of one duplicate for every 10 investigative samples or one field duplicate sample per sampling event if less than 10 investigative samples are collected.

Table 1 - Analytical Methods and Sample Requirements

MATRIX	CONTAINER	PRESERVATIVE	ANALYTE	VOLUME OR MASS REQUIRED	METHOD REFERENCE	MDA [a]
Soil	0.5 liter large-mouth Nalgene jar or plastic ziplock bag	None	Isotopic Uranium	< 10 g	EML U-02 Modified	<1.0 pCi/g [b, c]
			Isotopic Thorium	< 10 g	EML Th-01 Modified	<1.0 pCi/g [c]
			Gamma emitters including: Bi-214 & Pb-214 (Ra-226) Ac-228 (Ra-228), and K-40	400-500 grams	LANL ER-130 Modified	<1.0 pCi/g [c]
Water	1 Gallon Cubitainer	pH <2.0 HNO_3	Gross Alpha & Beta	Two gallons in 1-Gal Cubitainers	EPA 900.0 Modified or EPA 900.1 Modified [d]	<5 pCi/L
			Isotopic Thorium		EML Th-01 Modified	<1.0 pCi/L
			Radium-226		EPA 903.0 Modified	<1.0 pCi/L
			Radium-228		EPA 904.0 Modified	<2.0 pCi/L
Air	47mm Filter	None	Gross Alpha & Beta	Air volume sampled $\geq 1 \times 10^8$ mL	EPA 900.0 Modified	$<5x10^{-14}$ µCi/mL [e, f]
			Isotopic Thorium		EML Th-01 Modified	$<5x10^{-14}$ µCi/mL [e, f]

[a] MDA = method detection activity

[b] pCi = picoCuries

[c] Standard MDA. Lower MDA's available.

[d] Dependent on dissolved solids content.

[e] uCi = microCuries

[f] Dependent on volume of air sampled.

4.10 SAMPLE HANDLING AND SHIPPING

Each sample will be placed in the sample container indicated on Table 1 and sealed. A sample label will be placed on the outside of the container. The sample label will include the unique sample identifier discussed below, client name, project location, analyses to be performed, any preservative included with the sample, the collection date and time, and the name of the person who collected the sample.

To be consistent with the system used in previous sampling campaigns, unique sample identifiers will consist of an alpha-numeric code including the area label, the borehole identifier, the sample type and matrix, followed by the sample depth. The numeric portion of the sample identifier describing the depth will be separated from the borehole information by a dash "-". The starting and ending depths will be separated by a dash. The identifiers expected for this sampling program are listed below:

- Area label: Area 1 (A1)
- Borehole ID: A four digit descriptor of the borehole location, such as 12-03 for the third borehole along corridor 12 or equivalent. Note the 2-digit number designating numerical order along the corridor (01, 02, ... 10, etc.). This is desirable when sorting results for presentation.
- Sample Type and Matrix: IS (investigation soil)
- Sample Depth: This will consist of start and stop sample depths in feet with a dash between the two depths, such as 00.0-00.5 (0-6 inches). Note – grab samples of soil will have only one depth value associated with them (00.0-00.0).

For example, a soil sample collected in Area 1 (A1) along Path 4 (04) from the third borehole (03) for investigative purposes (IS) across a depth interval of 1 to 2 feet would be labeled:

A10403IS 01.0-02.0.

The sample containers will be stored in a secure location in a manner that maintains chain-of-custody requirements until such time as they are ready for shipment. If samples are selected for laboratory analysis, they will be logged on a chain-of-custody form and placed in a cooler.

A chain-of-custody form will accompany every shipment of samples to the analytical laboratory. The purpose of the chain-of-custody form is to establish the documentation necessary to trace possession from the time of collection to final disposal, and to identify the type of analysis requested. Any correction to the chain-of-custody record will be marked out with a single line, initialed and dated using black indelible ink by the person making the correction. Each chain-of-custody form will include signatures of the appropriate individuals indicated on the form. Shipping to the analytical laboratory will be via common courier directly to the laboratory.

The chain-of-custody form for that shipment will be placed in the cooler until the cooler is shipped. Prior to sealing the cooler, the cooler will be surveyed with a Ludlum Model 19 portable gamma radiation detector or equivalent and the maximum reading will be recorded on the chain-of-custody form. The original chain-of-custody form will be placed in the cooler and a copy retained at the Site. The cooler will be completely and securely sealed prior to shipment and a custody seal will be adhered on a side of the cooler from the lid to the body of the cooler. The seal will be signed and dated and clear packing tape placed over the seal. All samples will be packaged and shipped to the laboratory in accordance with USDOT regulations (see Auxier & Associates Procedure 3.8 "Sample Chain of Custody" in **Appendix A**).

4.11 Sample Processing and Analysis

Samples will be sent to Eberline Services Oak Ridge Laboratory for analysis. The samples will be received at the laboratory by the sample custodian. The custody-sealed coolers containing the samples will be opened and the contents inspected against the chain-of-custody form. Chain-of custody forms will be reviewed for completeness, and samples will be logged and assigned a unique laboratory sample number. Any discrepancies or abnormalities in samples will be noted by the laboratory and the Project Manager will be promptly notified.

All samples will be weighed prior to drying. After samples are dry, the samples will be reweighed and then ground to promote homogeneity. Results of the sample analyses are not expected to be received for four to six weeks from the time the samples are received by Eberline Services.

Investigative and field duplicate samples will be analyzed for the parameters using the methods listed on Table 1. Laboratory quality control (QC) samples will be prepared at the laboratory and analyzed along with the field samples to monitor the accuracy and precision of analysis. Quality Control and Quality Assurance internal to the Eberline Services Oak Ridge Laboratory; performance and system audits; control and maintenance of measurement and test equipment; data reduction, verification, reporting, and management; document control; and corrective action are included in the Oak Ridge Laboratory Quality Assurance Program Manual (Eberline, 2013), which is provided with this Work Plan as **Appendix B**. The Eberline Oak Ridge Laboratory successfully participates in annual Mixed Analyte Performance Evaluation Program (MAPEP) performance testing such as that conducted by the Department of Energy.

5 HEALTH AND SAFETY MONITORING

Procedures to support and monitor worker health and safety will be implemented in conjunction with any work performed at the Site. It is expected that the same procedures that were used during the Phase 1 GCPT investigation will also be used during Phases 1B, 1C and 2 work, with the exception that additional air monitoring activities will be conducted during the Phases 1B, 1C, and 2 programs. Additional details are contained in the HASP. A description of the particulate air monitoring activities is provided below.

In addition to the use of personal air monitoring pumps (see HASP), monitoring of possible radionuclide occurrences in airborne particulates will also be performed using fixed location air monitoring pumps and filters. Use of fixed location air monitoring pumps and filters allows for use of larger pumps which can sample a larger air volume than can be achieved using the more portable personal air monitoring pumps. This results in a larger particulate sample which generally produces a lower detection limit than the other methods used on this project.

Fixed location air monitoring will be performed using RADeCO H809-C air samplers (or equivalent) with 47 millimeter filters. These samplers include a two stage turbine blower capable of sampling at rates of 1 to 5 cubic feet per minute (30 to 140 liters per minute). The advantage of using these types of samplers is that they are light weight and can be operated using battery power and therefore can be easily located and re-located to meet the specific monitoring needs of the various investigative activities.

Fixed location air monitoring will be conducted at two locations during performance of the work including adjacent to the field trailer located along the south side of Area 1 and adjacent to the Bridgeton Landfill transfer station located to the west of Area 1. In addition, fixed location air monitoring will be performed at a third location along the downwind side of the boundary of the specific work area. The down-wind boundary placement will generally provide a worst-case indication of concentrations in air adjacent to the investigative activity being monitored. The location of this third monitoring station will vary depending on the specific investigative activities being conducted each day.

The primary purpose of the fixed location air monitors is to collect data to assess worker doses. They are therefore operated primarily during the investigative activities, anticipated to occur over a period of 60 to 80 hours per week. Filters will be collected weekly (or every other week if necessary to obtain sufficient sample volume to support low minimum detectable activity levels – see additional discussion below) and counted on-site using a Ludlum Model 2929 with a 43-10-1 alpha/beta detector for screening/operational monitoring purposes in accordance with the requirements set forth in the HASP.

Filters from the fixed location air monitoring stations will also be sent to the Eberline Services Oak Ridge, TN laboratory for analysis using low-background counters. The results will be used to report worker dosimetry for each phase of the investigation. Results will be compared to derived air concentrations of radionuclides for occupational exposure established by the Nuclear Regulatory Commission (NRC) [10 CFR Part 20, Appendix B, Table 1].

Pursuant to a request from EPA, the filters will also be analyzed for specific radioisotopes and the results will be compared to the effluent concentrations for air established by the NRC (10 CFR Part 20, Appendix B, Table 2) for assessment and control of dose to the public.

Using the mix of radionuclides published in the Baseline Risk Assessment (Auxier, 2000), 70% of the dose from any exposure to dust will be from particles containing the alpha emitter Thorium-230. The average annual release limit for Thorium-230 in effluent air is $3x10^{-14}$ microcuries per milliliter (μCi/ml) [NRC in 10 CFR 20, Appendix B, Table 2; Note: occupational standards are listed in Table 1 of this NRC Appendix B]. Assuming all of the alpha emissions are from Thorium-230, then the minimum detectable concentration (MDC) required to determine compliance with the Thorium-230 effluent limit will be less than $3x10^{-14}$ μCi/ml. The expected MDC for a one week sample will be on the order of 1 to $2x10^{-14}$ μC/ml for a 45 hour sample. Extending the sample duration to two weeks will reliably produce a minimum detectable concentration for gross alpha of $1x10^{-14}$ μCi/ml.

6 PROJECT TEAM

This Work Plan was prepared at the request of Bridgeton Landfill, LLC by Auxier & Associates, Inc. (A&A), a wholly owned subsidiary of USA Environment, LP, Feezor Engineering, Inc. (FEI), and Engineering Management Support, Inc. (EMSI). Roles and responsibilities of these project team members as well as subcontractors are as follows.

6.1 BRIDGETON LANDFILL, LLC

Bridgeton Landfill, LLC will retain overall management for the project and will retain Feezor Engineering, Inc,. Auxier & Associates, Engineering Management Support, Inc. and other necessary subcontractors to provide services necessary to identify a proposed alignment and develop design information for an isolation/thermal barrier.

6.2 FEEZOR ENGINEERING, INC.

Feezor Engineering, Inc. (FEI) is the Project Manager selected to manage the investigation and coordinate required operations on and off the site. FEI will supply GPS coordinates for the selected sampling locations. FEI will verify that all geospatial data are correct and fully documented. FEI will determine that:

- Actual sample locations correspond to specified coordinates;
- Elevation and depth bgs data are available for all actual sample locations, and
- Coordinates, elevations and depths of any relocated sample locations are captured and documented.

FEI will supply a geologist/field engineer to accompany the field team and examine the soil cores. The geologist/field engineer will receive the cores from the driller, label them, and prepare geologic/engineering descriptions of the soil cores as they are produced by the drillers. FEI will provide maps and drawings using data collected. FEI will also develop the final report summarizing the findings of the Phase 1B, 1C, and 2 investigations.

6.3 AUXIER & ASSOCIATES, INC.

A&A personnel have responsibility for all radiological measurements described in this plan and collecting, packaging, and shipping samples to the analytical laboratory. A&A will collate, validate, manage, and analyze the radiological data produced by this sampling program and prepare and submit a report summarizing the results.

A&A will supply the RSO and Radiation Control Technician (RCT) [see RCT roles and responsibilities in Section 7], to be determined, who will manage and perform the radiological measurements and sampling described in this work plan and the HASP. Mr. Mike Bollenbacher, CHP of A&A will provide technical oversight on the radiological aspects of the field sampling and analytical activities.

6.4 ENGINEERING MANAGEMENT SUPPORT, INC.

Engineering Management Support, Inc. (EMSI) is responsible for investigation and evaluation of potential remedial alternatives for Operable Unit 1. EMSI will provide oversight of the isolation/thermal barrier investigation and technical consultation relative to occurrences of RIM in Area 1, the proposed investigative and health and safety monitoring activities, and evaluation of the results of the field and laboratory investigations. Because EMSI is responsible for OU-1 work, and the isolation/thermal barrier investigation is being performed under the Administrative Order on Consent (AOC) for OU-1, EMSI will also provide coordination between the investigative team and EPA and perform reporting required under the AOC.

6.5 DRILLING SUBCONTRACTOR

Frontz Drilling will be the drilling subcontractor for the sonic drilling activities. The drilling subcontractor will provide for soil sampling by installing minimum 2.5 inch diameter boreholes at surveyed and marked locations. The drilling subcontractor will insert plastic sleeves in the borehole after cores have been extracted to allow for downhole gamma logging of the boreholes. Frontz Drilling will supply all materials necessary to collect soil cores from those boreholes including direct push equipment capable of advancing boreholes to depths of up to 100 feet, flexible or rigid liners and end caps, borehole inserts, and any necessary support vehicles and portable work tables.

Any additional GCPT drilling that may be conducted in conjunction with Phase 1C will be performed by ConeTec, the drilling subcontractor that performed the Phase 1 GCPT work.

6.6 SURVEYING CONTRACTOR

Weaver Boos will provide land surveying as necessary to support task completion. Specifically, the proposed and actual locations of the borings will, to the extent that they do not coincide with previously surveyed drilling locations, be surveyed prior to and/or upon completion of borehole drilling activities.

6.7 ANALYTICAL LABORATORY

Eberline Services Oak Ridge Laboratory located in Oak Ridge, Tennessee (Eberline) will perform laboratory analyses of the soil/waste samples collected from the boreholes. Eberline will also analyze particulate samples obtained in conjunction with the air monitoring activities. Eberline is one of the nation's largest radiochemistry laboratory networks and offers comprehensive radiochemical analyses including environmental radiochemistry. Eberline holds numerous laboratory certifications, accreditations, and approvals; including National Environmental Laboratory Accreditation Program (NELAP) and Department of Energy Consolidated Accreditation Program (DOECAP). Eberline has previously and continues to provide radiochemistry analytical services in support of OU-1 monitoring activities at the Site.

7 CONTAMINATION SURVEYS AND DECONTAMINATION PROCEDURES

The potential to spread contamination will be mitigated by establishing readily identifiable areas around activities having the potential to encounter radiological materials. Access to these areas, called "Permitted Areas" in this work plan, will be controlled and limited to properly trained individuals who have read, understood, and signed the daily Radiation Work Permit governing activities in an area or areas. Equipment and personnel leaving these Permitted Areas will be surveyed as described below. If contamination is identified, the contamination will be removed and the equipment rechecked. This is an iterative process that will continue until equipment and personnel meet exit criteria.

7.1.1 Radiological Surveys

Surveys will be used to monitor and control exposures and the potential spread of contamination. The following subsections describe the surveys to be used and their requirements.

7.1.1.1 Baseline Entry Survey – Equipment

All vehicles and large equipment entering Area 1 will be surveyed by the Radiation Control Technician (RCT) for fixed alpha and beta contamination before their initial entrance into Area 1. The survey will be conducted using a Ludlum Model 2360 scaler/ratemeter with a Model 43-93 alpha/beta detector probe (or equivalent), as described in A&A Procedure 2.7 (**Appendix A**).

7.1.1.2 Permitted Area Exit Survey - Personnel

Personnel exiting a Permitted Area will have their shoes and clothing scanned upon leaving the area, as described in A&A Procedure 2.7. The name of the individual, the results of the exit survey, the location, and the times they entered and left the area will be recorded on a standard form such as A&A Form 11 (Personnel Monitoring Form) or a log sheet attached to a copy of the Radiation Work Permit. A reading of two (2) times the ambient background level will require decontamination before leaving the area.

7.1.1.3 Permitted Area Exit Survey - Equipment

Heavy equipment working inside a Permitted Area will be surveyed by the RCT before leaving the area. All surfaces in contact with soil will be scanned for alpha, beta and gamma surface activity with a Ludlum Model 12 survey meter coupled to a Model 44-9 alpha/beta/gamma pancake detector (or equivalent) as described in A&A Procedure 2.7. A reading of two (2) times the ambient background level will require the equipment to be decontaminated and resurveyed before it leaves the Permitted Area.

Sections of the downhole drilling equipment will be sampled with a swipe between sampling locations to detect any removable activity on the surface of the tool string. The swipe samples will be screened in the field with a Ludlum Model 12 survey meter coupled to a Model 43-5 alpha detector, or equivalent. A final measurement of alpha and beta activity on the smear will be performed using a Ludlum Model 2929 scaler coupled to a Ludlum Model 43-10-1 alpha/beta counter or a low-background alpha/beta counter such as an XLB-5.

7.1.1.4 Final Release Survey - Equipment

Equipment working inside a Permitted Area and equipment that might inadvertently contact contaminated soil outside a cleared easement will be surveyed by the RCT before leaving Area 1. All surfaces in contact with soil will be scanned for alpha and beta contamination with a Ludlum Model 2360 scaler/ratemeter coupled with a Model 43-93 probe (or equivalent) as described in A&A Procedure 2.7.

Removable contamination will be sampled by swiping 100 cm^2 areas on parts of the equipment that were in contact with soil surfaces as described in A&A Procedure 3.6. These smear samples will be counted with a Ludlum Model 2929 scaler coupled to a Ludlum 43-10-1 detector.

If contamination is found, the vehicle will be decontaminated until it meets final release standards listed in Table 2. The equipment identification and the final results will be recorded on the appropriate equipment release form from the A&A Procedures Manual and the equipment will be unconditionally released from Area 1.

Table 2 - Final Release Survey Limits for Equipment

Parameter	Acceptable Surface Contamination Levels [a]	Equivalent Meter Response in the Field [b]
Fixed Alpha (Ra-226 & Th-230)	100 dpm/100cm^2, average 300 dpm/100cm^2, maximum	20 cpm Mo 2360/Mo 43-93 60 cpm Mo 2360/Mo 43-93
Fixed Beta (U_{nat} & assoc. decay products)	5,000 dpm/100cm^2, average 15,000 dpm/100cm^2, maximum	750 cpm Mo 2360/Mo 43-93 2250 cpm Mo 2360/Mo 43-93
Removable Alpha	20 dpm/100cm^2, average	Na
Removable Beta	1,000 dpm/100cm^2, average	Na

[a] From U.S. Atomic Energy Commission's RegGuide 1.86 *"Termination of Operating Licenses for Nuclear Reactors,"* Table 1 Acceptable Surface Contamination Levels.

[b] Nominal values based on default efficiencies published by Ludlum Instruments on their web site (20% α, 15% β). Meter efficiencies may be reevaluated at the site.

7.1.2 Equipment Decontamination

All equipment (including but not limited to the drill rig) will be surveyed. If radioactive contamination is detected, the equipment will be decontaminated. A phased approach to decontamination will be employed to minimize the generation of solid waste and waste water.

7.1.2.1 Dry Decontamination

It is expected that any contamination will be associated with loose, removable dirt and mud that may attach to equipment surfaces during operations. If contamination is detected on equipment after operations are completed in a boring location, the equipment will be decontaminated before moving to the next boring location. Visual patches of dirt and mud will be removed from the contaminated surfaces of the equipment using damp wipes, brushes, and scrapers. Used decontamination supplies will be placed in marked containers or bags. The remainder of material removed during dry decontamination will be placed in a separate container with hard plastic or metal sides and staged for retrieval and sampling. Any solid radioactive waste generated will be packaged and characterized for handling as discussed in Section 7.1.2.3 .

7.1.2.2 Wet Decontamination of Equipment

If dry decontamination is not sufficient to meet release levels, the equipment will be moved to the radiological decontamination pad. Contaminated surfaces will be scrubbed with brushes and soapy water until they are visually clean. The equipment will be surveyed again for both alpha and beta surface activity. If fixed or removable activity exceeding the release limits is found, the contaminated surface will be decontaminated using more aggressive methods such as pressure washing or abrasive blasting until the release criteria are met.

7.1.2.3 Waste/Water Management

Water used to decontaminate equipment will be placed in marked holding tanks and/or drums, sampled, and packaged and shipped to a licensed, managed disposal site. The volume of sample required, sample container type, and preservative requirements for any water sample(s) are provided on Table 1. Decontamination water samples will be analyzed for gross alpha and beta and isotopic Uranium. If the gross alpha results are greater than 15 pCi/L, then the sample(s) will be analyzed further for Radium-226 and isotopic Thorium. Analytical methods and MDAs are included on Table 1.

Any solid radioactive waste generated will be packaged and characterized for shipping. This material will be shipped to a managed disposal/treatment facility that is permitted to receive the waste.

7.1.2.4 Final Housekeeping Wash-down

Any equipment released from Area 1 will be washed with water to remove visible dirt from its surfaces prior to its removal from the project. This final housekeeping can be performed in an uncontrolled area and any water generated from this final cleaning of previously released equipment will be considered unimpacted.

7.1.3 Decontamination Pads

Two separate decontamination pads were constructed during the Phase 1 GCPT investigation. A radiological decontamination pad was constructed near PVC-38. This pad will be used to decontaminate equipment failing the free-release radiological requirements and was constructed to contain solid waste and decontamination water.

A second pad was also constructed for general cleaning of equipment that has not been exposed to RIM materials. This gravel surface pad is located adjacent to the fence near the entrance road to Area 1.

8 QUALITY ASSURANCE

The various activities and requirements to be implemented to support collection of data of the quality necessary to support decision making for the isolation/thermal barrier investigation and design are presented in this work plan. This section provides an overview of the specific data quality objectives for the analytical laboratory data. A listing of where the various requirements of a quality assurance project plan (QAPP) are located in this work plan is also included. In addition, the specific data validation procedures to be employed to assess the quality of the data provided by the analytical laboratory are presented in this section.

8.1 ANALYTICAL DATA QUALITY OBJECTIVES

Samples of waste/soil material will be obtained and submitted to Eberline for determination of radionuclide activity levels. As discussed in Section 1.1.1 of this work plan, RIM is defined as materials that contain any of the following:

- Combined radium-226 and radium-228 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g);
- Combined thorium-230 and thorium-232 at levels greater than 5 pCi/g above background (e.g., 7.9 pCi/g); and
- Total uranium greater than 50 pCi/g plus background (e.g. 54.5 pCi/g) [EMSI, 2011].

The MDA levels for analytical methods listed on Table 1 should provide data of sufficient quality to allow for characterization of the waste/soil samples necessary to identify any occurrences of RIM in the areas being considered for construction of an isolation/thermal barrier.

Analytical data will also be developed to assess worker doses and verify that particulate concentrations of radionuclides in air do not pose a risk to the general public. Specifically, the particulate filter samples will be submitted to Eberline for analysis of thorium-230. As discussed in Section 6 of this work plan, the effluent limit for airborne thorium-230 established by the NRC (10 CFR Part 20 Appendix B, Table 2) is $3x10^{-14}$ µCi/ml. Therefore, the minimum detectable concentration (MDC) required from the analytical laboratory to determine compliance with the thorium-230 effluent limit will be less than $3x10^{-14}$ µCi/ml. Assuming that all of the alpha emissions result from decay of thorium-230, the MDC for gross alpha in a sample containing 1.8 x 108 mL (60 liters per minute for 50 hours) will be $2.8x10^{-14}$ µCi/ml. Extending the sample duration to two full weeks (100 to 120 hours) will produce a sample volume of approximately 3.6 x 10^{8} or more, and result in minimum detectable concentrations for gross alpha and thorium-230 of 1 to 2 x 10^{-14} µCi/ml. Therefore, the proposed sampling and analyses should provide data of sufficient quality to evaluate potential particulate occurrences of radionuclides in air.

8.2 QUALITY ASSURANCE PROJECT PLAN REQUIREMENTS

EPA has established guidance relative to the requirements for Quality Assurance Project Plans (EPA, 2002). A listing of the QAPP requirements and the location in this work plan where these requirements are addressed (if and as appropriate for the scope of the investigations) are presented on Table 3.

8.3 DATA VALIDATION

The data validation process will consist of evaluation of the results of individual samples collected and analyzed to determine if results are within acceptable limits. These quantitative or qualitative limits of acceptability are defined for Precision, Accuracy, Representativeness, Comparability, and Completeness (PARCC), as discussed below.

Precision: Precision is defined as the agreement between a set of replicate measurements without assumption or knowledge of the true value. Agreement is expressed as either the Relative Percent Difference (RPD) for duplicate measurements, or the range and standard deviation for larger numbers of replicates. Data regarding precision are obtained by analyzing duplicate or replicate samples.

Accuracy: Accuracy is a measure of the closeness of a sample analysis result to the "true" value. Accuracy of sample analyses is evaluated using laboratory control samples that are prepared and analyzed by the analytical laboratory as part of the analyses of the various batches (lots) of samples.

Representativeness: Representativeness is the degree to which data accurately and precisely represent characteristics of a population, parameter variations at a sampling point, or an environmental condition. For this investigation, representativeness will be ensured by the selection of sampling locations in accordance with the goals of the sampling design requirements presented in Section 1.2.

Comparability: Data are comparable if collection techniques, measurement procedures, methods, and reporting units are equivalent for the samples within a sample set. These criteria allow comparison of data from different sources. Comparable data will be obtained by specifying standard units for physical measurements and standard procedures for sample collection, processing, and analysis.

Completeness: Data are considered complete when a prescribed percentage of the total intended measurements and samples are obtained. Analytical completeness is defined as the percentage of valid analytical results requested. For this investigation, collection of samples at a minimum of 80% percent of the planned sampling locations must be obtained to achieve a satisfactory level of data completeness.

Level III data validation will be performed consisting of manually examining data deliverables to determine data quality for the analytical results for field investigative and duplicate samples. Radionuclide data will be validated in general accordance with the guidelines and criteria specified in the MARLAP Manual (EPA, 2004). Data validation will include application of appropriate data qualifiers to the analytical results based on adherence to method protocols and project-specific QA/QC limits.

The following elements will be reviewed for compliance as part of the data validation:

- Methodology;
- Holding Times;
- Calibration;
- Blanks;
- Spikes;
- Duplicates;
- LCSs;
- Practical Quantitation Limits;
- Analyte Identification; and
- Analyte Quantification.

During the subsequent data evaluation process, the sampling, analysis, and data collection documentation will also be reviewed for completeness and consistency with data quality objectives. Data validation reports will be reviewed to identify any limitations associated with the analytical data.

Table 3 – Crosswalk Between Quality Assurance Project Plan Requirements & Workplan Sections

Element No.	Element Description	Work Plan Page/Section	Comments
A1	Title and Approval Sheet	Page i	Note approval of the work plan will be separately provided by letter or e-mail from EPA
A2	Table of Contents	Page ii	
A3	Distribution List	Transmittal letter	
A4	Project/Task Organization	Sections 1.2 and 10	
A5	Problem Definition and Background	Section 1.1	
A6	Project/Task Description	Section 1.2	
A7	Quality Objectives and Criteria	Section 8.1	
A8	Special Training/Certifications	Not applicable	
A9	Documentation and Records	Section 9	
B1	Sampling Process Design	Section 4	
B2	Sampling Methods	Section 4	
B3	Sample Handling and Custody	Section 4.10	
B4	Analytical Methods	Table 1	
B5	Quality Control	Section 4.9	
B6	Instrumentation/Equipment Testing, Inspection, and Maintenance	Health and Safety Plan	
B7	Instrument/Equipment Calibration and Frequency	Health and Safety Plan	
B8	Inspection/Acceptance of Supplies and Consumables	Not applicable	
B9	Non-direct Measurements	Section 4.8	
B10	Data Management	Section 9	
C1	Assessments and Response Actions	Not applicable	Work will be completed prior to receipt of analytical results. Any data quality issues identified during data validation will be addressed directly with the laboratory. Sample holding times are sufficiently long to all for re-analysis/additional analyses will be performed to meet project objectives if necessary.
C2	Reports to Management	Section 9	
D1	Data Review, Verification and Validation	Section 8.3	
D2	Verification and Validation Methods	Section 8.3	
D3	Reconciliation with User Requirements	Section 8.3	

9 REPORTING

Field investigation activities and the findings from these efforts will be summarized in a stand-alone Subsurface Investigation Summary Report.

The field data (boring logs, soil screening data, survey data, etc.) will be recorded daily on paper forms and log books. These paper records will be maintained in a managed repository such as an office or a climate controlled storage facility for future reference.

Analytical results will be sent in electronic format from the laboratory to Auxier & Associates. Laboratory analytical data will be recorded digitally and maintained in a relational database. Full Level III laboratory reports containing documentation of the analytical process, QA/QC data and analytical instrument performance will be sent in electronic or paper format from the laboratories to Auxier & Associates and EMSI. These analytical reports will include:

- Copies of completed chain of custody forms,
- Instrument calibration and/or instrument quality control records,
- Results for blanks and spikes associated with the reported results,
- Results for duplicates,
- Sufficient documentation to reproduce calculated results from instrument responses, and
- A case narrative describing the analytical process used to produce the published results.

All of the laboratory data will be validated by examining the test results. The laboratory reports and validation packets will be maintained at Auxier & Associates.

Information regarding the progress of the field work and sampling activities will be provided in the monthly progress reports for West lake Landfill Operable Unit 1 (OU-1) prepared by EMSI. Analytical reports will also be provided by EMSI as they are received in conjunction with submittal of the monthly progress reports for OU-1.

FEI will author a final report summarizing:

- Field preparations;
- Boring locations and sample locations;
- Lithology logs;
- Analytical testing and validation results; and
- A discussion on the feasibility of the isolation/thermal barrier alignment.

10 ANTICIPATED PROJECT SCHEDULE

An anticipated project schedule tasks are provided below. Significant factors affecting the overall project schedule including drill rig availability, weather conditions, time required to perform laboratory analyses to achieve the minimum detectable activity levels required to meet the project data quality objectives, time required to validate the laboratory analytical data, time required to review the results of the field and laboratory data and finalize the scope of work and specific sampling requirements for the subsequent phase of work. Laboratory reports are expected to be received four to six weeks after submission of samples. Data validation is anticipated to require two to four weeks and is dependent upon the validator's schedule at the time the analytical reports are made available. The investigation summary report is anticipated to be complete and ready for submittal to the EPA one month after the analytical results are received and validated.

As discussed with EPA and elsewhere in this report, it is the intent of Bridgeton Landfill to work cooperatively with EPA to maximize efficiencies and minimize downtime between investigative steps. To this goal, this work plan will be updated through addenda addressing the next investigational steps and the parties will work cooperatively to streamline comments and revisions to ensure that work can proceed efficiently to completion. The schedule will be optimized with concurrence from the EPA through weekly communication.

The tasks are listed below with the expect field times. Overlapping tasks will occur. The project tasks include:

- Phase 1B Field Investigation - 20 days
- Phase 1B Analytical Testing 30 days
- Phase 1B Data Validation 20 days
- Phase 1C Field Investigation 15 days
- Phase 2 Field Investigation - 40 days
- Phase 2 Analytical Testing 30 days
- Phase 2 Data Validation 20 days
- Final Report Preparation 20 days (after all analytical results are fully validated)

11 REFERENCES

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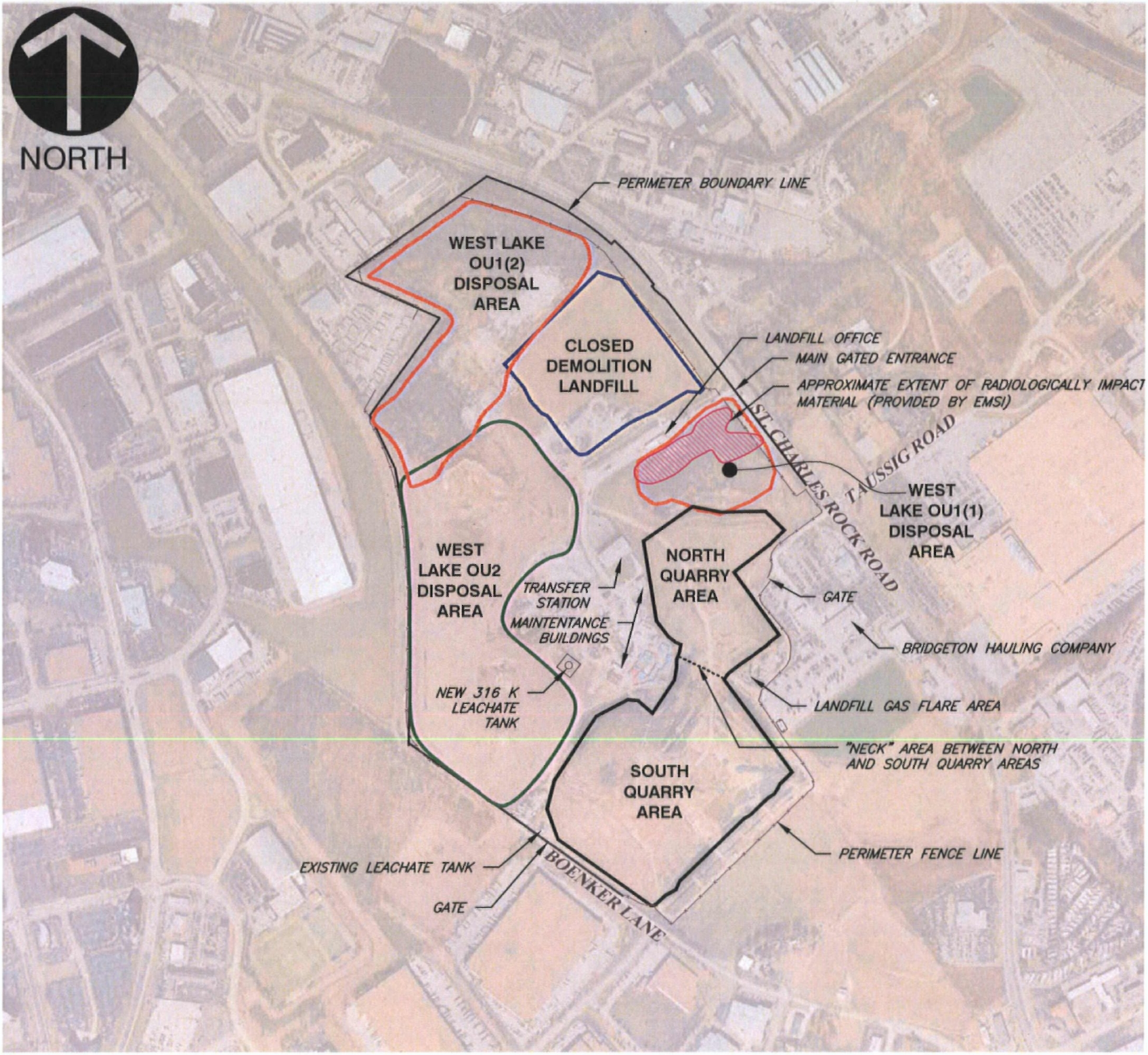
EPA, 1997, First Amendment to Administrative Order on Consent, Docket No. VII-93-F-0005, July 16.

FIGURES



REFERENCE

1. AERIAL IMAGERY PROVIDED BY EAST WEST GATEWAY COORDINATING COUNCIL OF MISSOURI AND ILLINOIS, COLLECTED IN LATE FEBRUARY AND EARLY MARCH OF 2012.

2. BOUNDARY INFORMATION PROVIDED BY SHERBUT-CARSON & ASSOCIATES, P.C. DRAWING NAME-1111 LEASE EXHIBIT.DWG RECEIVED ON 03/04/2013

SCALE IN FEET

0 1000 2000

BRIDGETON LANDFILL, LLC
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI

FACILITY MAP

DRAWN BY: MSP	CHECKED BY: MRB	APPROVED BY: DRAFT	FIGURE NO.:
DATE: JUN. 2013	DWG SCALE: 1"=1000'	PROJECT NO: 131-178.0001	1

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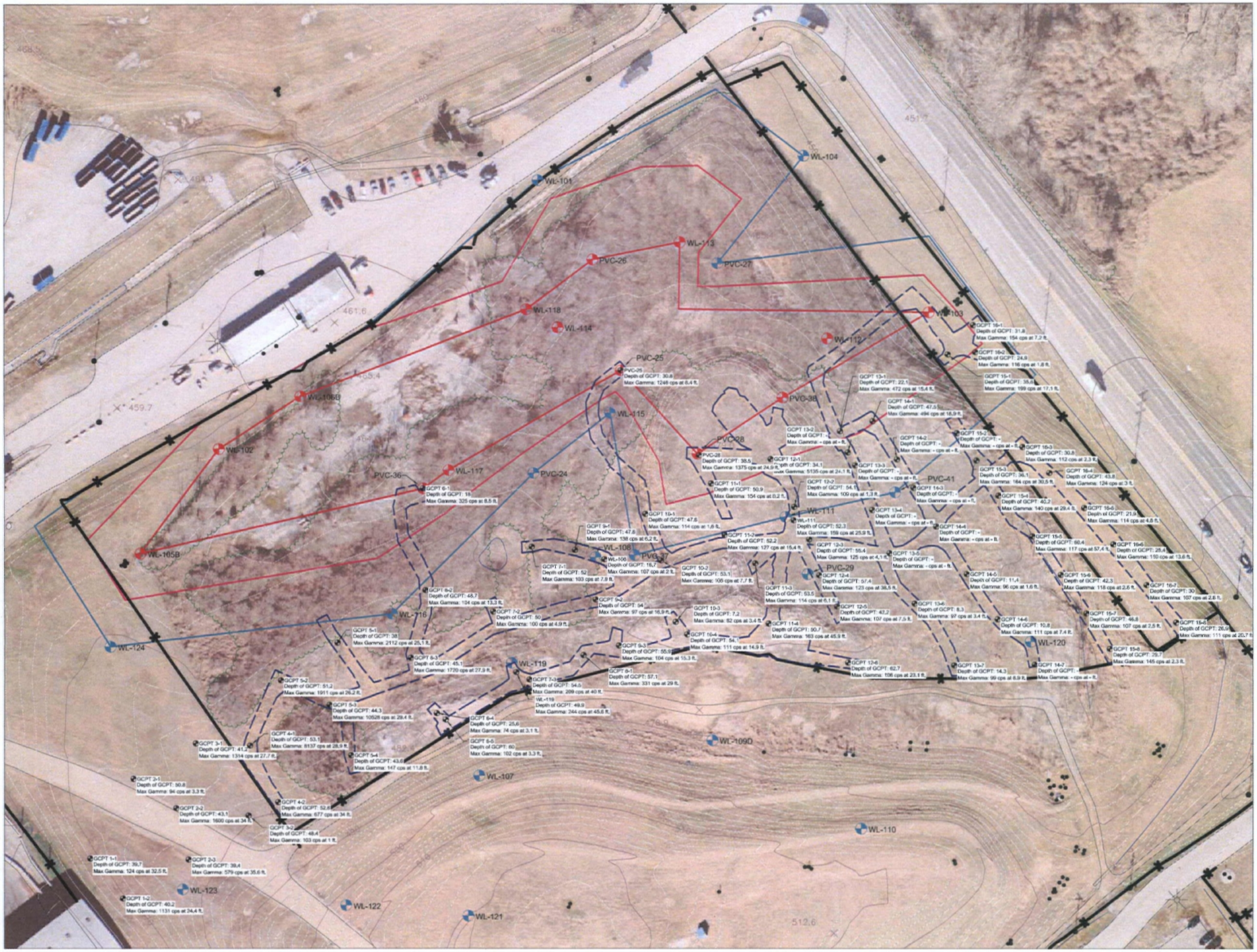


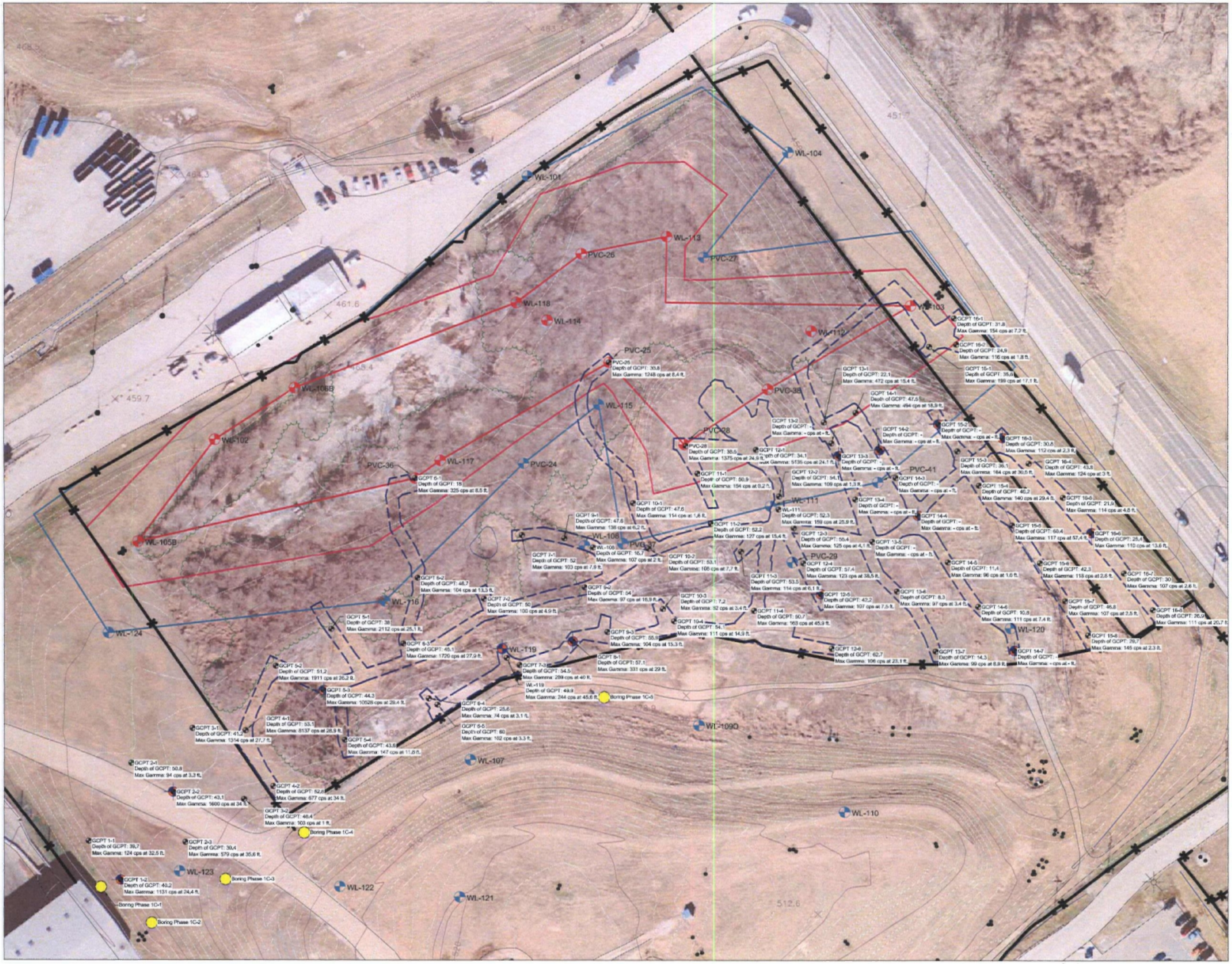
GCPT Boring	Date Completed	Maximum Depth	Maximum Gamma Count	Depth of Maximum Gamma Count
		(feet)	(Counts per Second)	(feet)
GCPT - 1.1	11/25/2013	39.7	124.0	32.5
GCPT - 1.2	11/25/2013	40.2	1,131.3	24.4
GCPT - 2.1	11/24/2013	50.8	93.5	3.3
GCPT - 2.2	11/24/2013	43.1	1,600.0	34.0
GCPT - 2.3	11/24/2013	39.4	578.7	35.6
GCPT - 3.1	11/24/2013	41.2	1,313.5	27.7
GCPT - 3.2	11/24/2013	48.4	103.1	1.0
GCPT - 4.1	11/14/2013	53.1	8,136.6	28.9
GCPT - 4.2	11/14/2013	52.8	677.4	34.0
GCPT - 5.1	11/19/2013	38.0	2,112.3	25.1
GCPT - 5.2	11/18/2013	51.2	1,911.4	26.2
GCPT - 5.3	11/19/2013	44.3	10,527.7	29.4
GCPT - 5.4	11/19/2013	43.6	147.0	11.8
GCPT - 6.2	11/19/2013	48.7	104.3	13.3
GCPT - 6.3	11/19/2013	45.1	1,720.3	27.9
GCPT - 6.4	11/16/2013	25.6	73.9	3.1
GCPT - 6.5	11/16/2013	60.0	101.8	3.3
GCPT - 7.1	11/15/2013	52.0	103.4	7.9
GCPT - 7.2	11/19/2013	50.0	100.2	4.9
GCPT - 7.3	11/16/2013	54.5	209.3	40.0
GCPT - 8.1	11/15/2013	57.1	330.9	29.0
GCPT - 9.1	11/15/2013	47.6	138.0	6.2
GCPT - 9.2	11/19/2013	54.0	97.1	16.9
GCPT - 9.3	11/15/2013	55.9	103.8	15.3
GCPT - 10.1	11/19/2013	47.6	113.8	1.6
GCPT - 10.2	11/20/2013	53.1	108.1	7.7
GCPT - 10.3	11/18/2013	7.2	81.5	3.4
GCPT - 10.4	11/18/2013	54.1	110.7	14.9
GCPT - 11.1	11/21/2013	50.9	153.5	0.2
GCPT - 11.2	11/20/2013	52.2	126.9	15.4
GCPT - 11.3	11/20/2013	53.5	114.3	6.1
GCPT - 11.4	11/18/2013	50.7	163.2	45.9
GCPT - 12.1	11/20/2013	34.1	5,135.0	24.1
GCPT - 12.2	11/20/2013	54.1	109.1	1.3
GCPT - 12.3	11/21/2013	55.4	124.6	4.1
GCPT - 12.4	11/21/2013	57.4	122.9	38.5
GCPT - 12.5	11/21/2013	42.2	107.2	7.5
GCPT - 12.6	11/18/2013	62.7	106.3	23.1
GCPT - 13.1	11/21/2013	22.1	471.7	15.4
GCPT - 13.2	11/21/2013	No boring refusal less than 5'		
GCPT - 13.3	11/21/2013	No boring refusal less than 5'		
GCPT - 13.4	11/21/2013	No boring refusal less than 5'		0.0
GCPT - 13.5	11/22/2013	No boring refusal less than 5'		0.0
GCPT - 13.6	11/22/2013	8.3	96.7	3.4
GCPT - 13.7	11/22/2013	14.3	98.8	8.9
GCPT - 14.1	11/22/2013	47.5	494.0	18.9
GCPT - 14.2	11/22/2013	No boring refusal less than 5'		
GCPT - 14.3	11/22/2013	No boring refusal less than 5'		
GCPT - 14.4	11/22/2013	No boring refusal less than 5'		
GCPT - 14.5	11/22/2013	11.4	96.2	1.6
GCPT - 14.6	11/22/2013	10.8	110.9	7.4
GCPT - 14.7	11/22/2013	No boring refusal less than 5'		
GCPT - 15.1	11/23/2013	35.6	199.0	20.3
GCPT - 15.2	11/23/2013	No boring refusal less than 5'		
GCPT - 15.3	11/23/2013	36.1	163.8	30.5
GCPT - 15.4	11/22/2013	40.2	140.0	29.4
GCPT - 15.5	11/22/2013	60.4	117.4	57.4
GCPT - 15.6	11/22/2013	42.3	118.3	2.6
GCPT - 15.7	11/22/2013	46.8	107.4	2.5
GCPT - 15.8	11/22/2013	29.7	145.4	2.3
GCPT - 16.1	11/23/2013	31.8	153.8	7.2
GCPT - 16.2	11/23/2013	24.9	115.8	1.8
GCPT - 16.3	11/23/2013	30.8	112.4	2.9
GCPT - 16.4	11/23/2013	43.8	124.1	3.0
GCPT - 16.5	11/23/2013	21.9	114.4	4.8
GCPT - 16.6	11/23/2013	25.4	110.0	13.6
GCPT - 16.7	11/23/2013	30.0	106.9	2.6
GCPT - 16.8	11/23/2013	26.9	110.8	20.7
PVC-25	11/14/2013	30.8	1,248.0	8.4
PVC-28	11/14/2013	38.5	1,375.2	24.9
PVC-36 (GCPT - 6.1)	11/14/2013	18.0	324.5	8.6
WL-108	11/15/2013	16.7	106.8	2.0
WL-111	11/13/2013	52.3	159.0	25.9
WL-119	11/15/2013	49.9	243.6	45.6

0 40 80 Feet

LEGEND

- GCPT LOCATION
- ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF ELEVATED DOWNHOLE READINGS
- NON-ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF NON-ELEVATED DOWNHOLE READINGS
- INTERPOLATED RIM LIMITS
- FENCE
- ROCK

WEST LAKE LANDFILL 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	WEST LAKE LANDFILL OU-1 AREA 1 RIM INVESTIGATION	Engineering for a Better World FEEZOR ENGINEERING, INC.	DECEMBER 2013 DESIGNED BY: PAL APPROVED BY: DBF	DRAWING NO. 2
GCPT STATUS through 11-29-13			REVISION / DATE	



Feet

LEGEND

- GCPT LOCATION
- ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF ELEVATED DOWNHOLE READINGS
- NON-ELEVATED DOWNHOLE GAMMA READING
- BOUNDARY OF NON-ELEVATED DOWNHOLE READINGS
- INTERPOLATED RIM LIMITS
- FENCE
- ROCK
- PROPOSED PHASE 1B SONIC BORING LOCATION
- PROPOSED PHASE 1C BORING LOCATION (EITHER SONIC DRILLED OR GCPT)

WEST LAKE LANDFILL
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI 63044

WEST LAKE LANDFILL OU-1
AREA 1 RIM INVESTIGATION

PROPOSED PHASE 1B AND 1C BORING LOCATIONS

Engineering for a Better World
FEEZOR ENGINEERING, INC.

DECEMBER 2013
DESIGNED BY: PAL
APPROVED BY: DRF

REVISION | DATE

PROJECT NUMBER | FILE PATH

DRAWING NO.
3

Appendix A

Auxier & Associates Radiological Surveying and Sampling Procedures

PROCEDURE 2.1
INSTRUMENTATION: CALIBRATION & QUALITY CONTROL

1.0 PURPOSE

1.1 To describe the general approach to calibration and quality control checks of survey instruments.

2.0 RESPONSIBILITIES

2.1 The Site Survey Manager is responsible for assuring that this procedure is implemented.

2.2 Survey team members are responsible for following this procedure.

3.0 PROCEDURE

3.1 Calibration

3.1.1 Instruments to be used for quantitative measurements are source calibrated a minimum of every twelve months; more frequent calibration may be necessary for some projects or applications to satisfy requirements of the responsible regulatory agency or following repair of the instrument. Exception: A properly calibrated Pressurized Ionization Chamber may be used as a secondary standard to calibrate response of a gamma detector, relative to true exposure rate (refer to Procedure 2.5).

3.1.2 Calibration is to be performed with standards traceable to the National Institute of Standards and Technology (NIST) or other industry recognized standards organizations.

3.1.3 Records will be maintained for each detector and readout instrument, detailing the calibration and maintenance history. Originals of calibration records are to be maintained at the Knoxville, Tennessee facility; however, copies should accompany instruments to the field measurement location.

3.1.4 Calibration will be performed by the instrument manufacturer or other outside organization. A&A will provide directions/specifications for calibration by outside agencies. An exception to manufacturer calibration is calibration of gamma detectors, using a pressurized ionization chamber (see Procedure 2.5). Calibration for response of surface contamination monitors to radionuclides or radionuclide mixtures for which commercial calibration services are not available or practical may necessitate in-house determination of source response or theoretical calculation of response, based on estimated parameters, e.g., from draft NUREG-1507. If in-house calibration is performed, detailed procedures will be developed, approved by the Field Survey Resources Committee, and placed in the appropriate project file.

3.1.5 Instruments, such as a pressurized ionization chamber, may be calibrated as a detector/readout combination; if calibrated in this manner, quantitative measurements are made only with the components and parameters for which the combination was calibrated.

3.1.6 Detectors and readouts, which are individual pieces of equipment, are usually calibrated separately; however, a calibrated detector may be used with various calibrated readout instruments, even if a specific source calibration of the combination has not been performed. To enable such use, the baseline response of the calibrated detector to a designated check source is determined immediately after return of the detector from calibration, using a readout instrument (for which the calibration is also current) with the operating parameters, e.g., high voltage and threshold (input discriminator), set according to those parameters at which the detector was calibrated.

Where possible, for an analog readout instrument, select a scale on which the source will provide a reading of between half- and full-scale; for an integrating digital readout instrument select a count time which will result in accumulation of at least 10,000 counts. Determine and record on the appropriate form, the gross and net instrument response on the Baseline Response record form. For instruments that will be operated in the scaler mode, repeat the determination ten times and calculate the average; one reading is recorded for instruments to be operated in the ratemeter mode. A range of ± 20 % of that response to the designated source is established as the criterion for evaluating acceptance of other readouts (with properly set operating parameters) with that detector. Each detector/readout combination, which satisfies the acceptance criterion for the designated baseline check source may be assumed to be responding with the efficiency established for the detector. This record is filed with other detector response, calibration, and maintenance information.

3.2 Quality Control Check

3.2.1 Equipment

3.2.1.1 Instrument (detector and/or readout)

3.2.1.2 Cables

3.2.1.3 Check source

3.2.1.4 Pulse generator (Ludlum Measurements, Inc. Model 500)

3.2.1.5 Calibration documents

3.2.1.6 Forms for Baseline Detector Response and Instrument QC Check

3.2.2 Procedure

3.2.2.1 This procedure is applicable to all field survey instruments.

3.2.2.2 Quality control checks are performed prior to sending instruments to the field, at the beginning and end of each day of data acquisition, upon return of the instrument from a field assignment, at any time instrument factors (batteries, cables, operating parameters, etc.) which could effect the instrument response are altered, and whenever the performance of an instrument is in question.

3.2.2.3 Assure that the baseline response has been established, that the response to the check source has been determined, and that the response was satisfactory (refer to Step 3.1.6).

3.2.2.4 All equipment associated with instrument operation (e.g., tubing, flow meters, collimators, headphones, etc.) should be in place when testing response to assure proper operation of the complete system.

3.2.2.5 Turn the instrument on and check batteries. Record result on Instrument QC check form; replace batteries and repeat test, if necessary.

3.2.2.6 Check high voltage, threshold, and other operating parameters; record values and, if necessary, adjust parameters to predetermined values and repeat checks. For some instruments it will be necessary to use the Ludlum Pulse Generator to determine and adjust the operating parameters.